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→ 2018 OCEAN SALINITY SCIENCE CONFERENCE

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Impact of Horizontal Salinity Gradients on the Bay of Bengal Circulation & Mesoscale Variability

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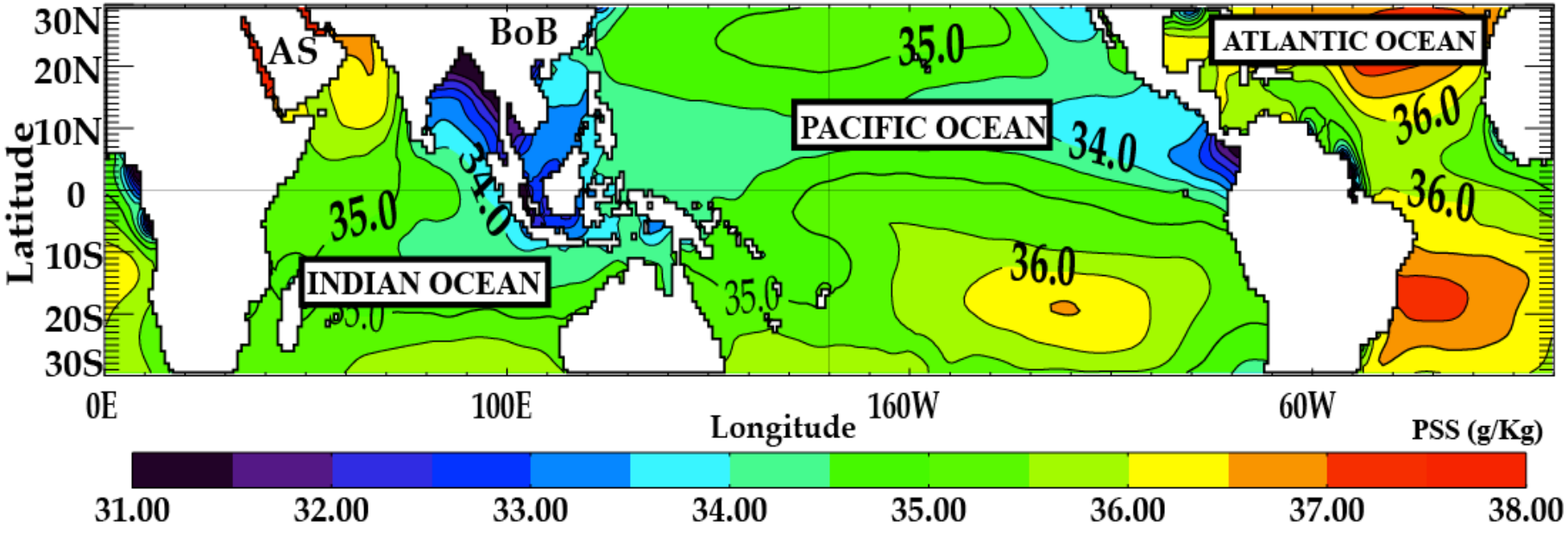
Related talks by Akhil V P (Jerome Vialard, 6th 16.00) & A V S Chaitanya (8th 15.30)

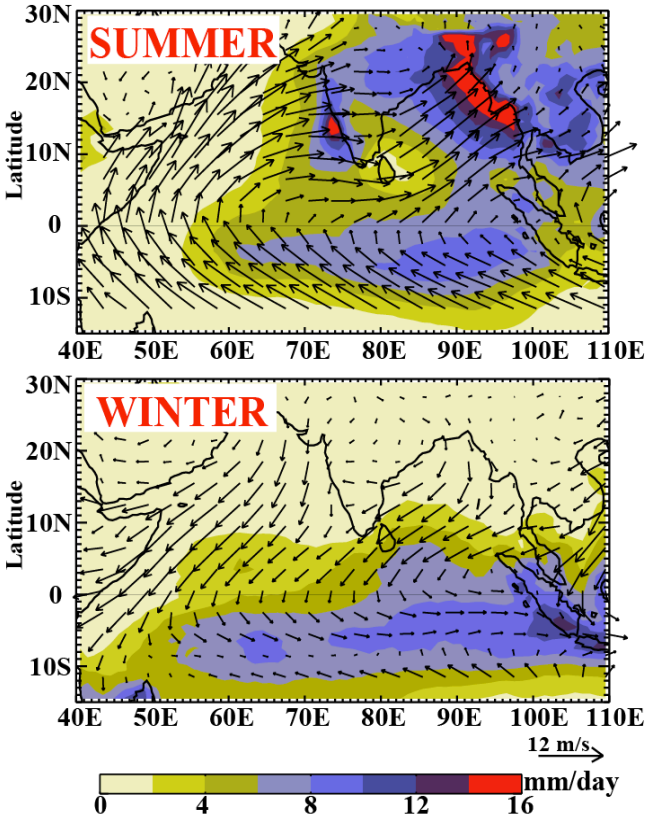
Introduction



❖ Bay of Bengal (BoB) – One of the freshest region in the tropical Ocean.

Introduction

Precipitation & surface wind



Seasonally reversing monsoon drives the climate of the northern Indian Ocean.

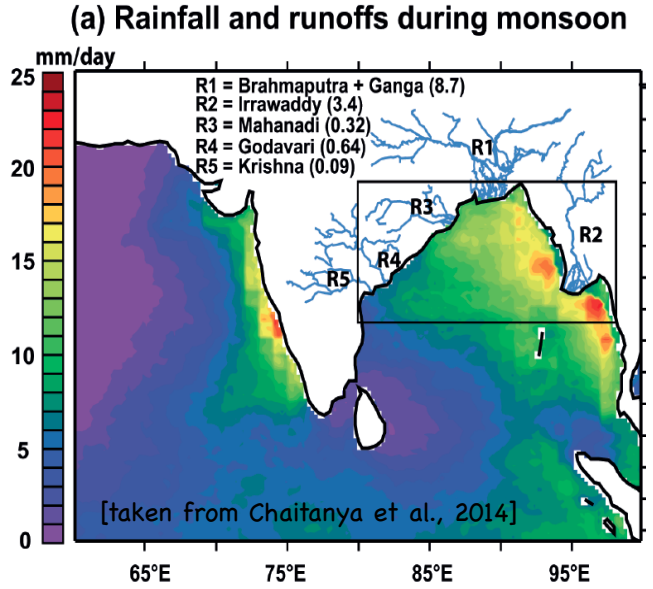
Summer Monsoon

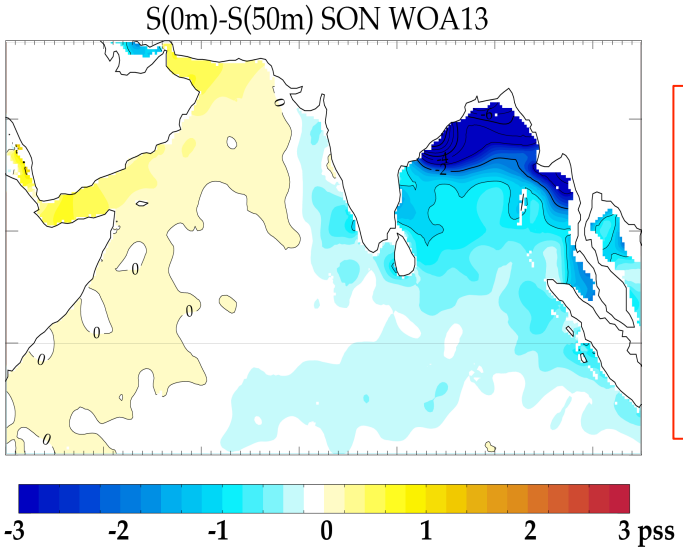
- Strong southwesterly winds.
- Heavy rainfall.

Winter Monsoon

- Cold dry northeasterly winds.
- Less rainfall.

Introduction





Strong surface freshening

↓

Stable stratification

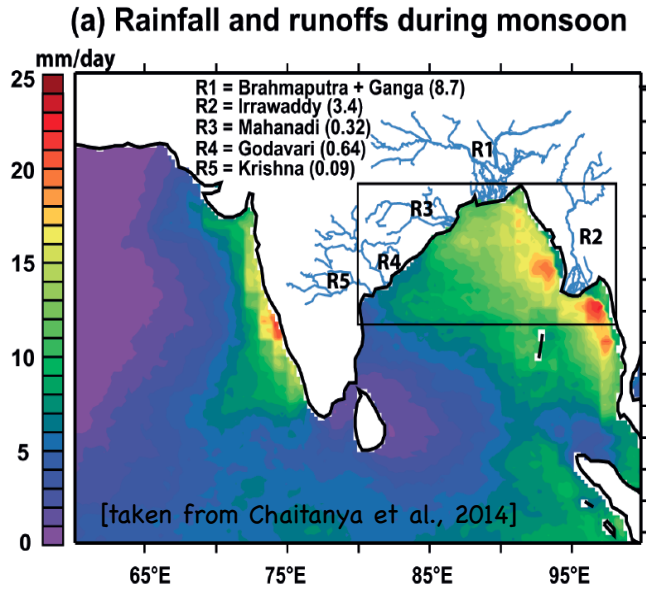
↓

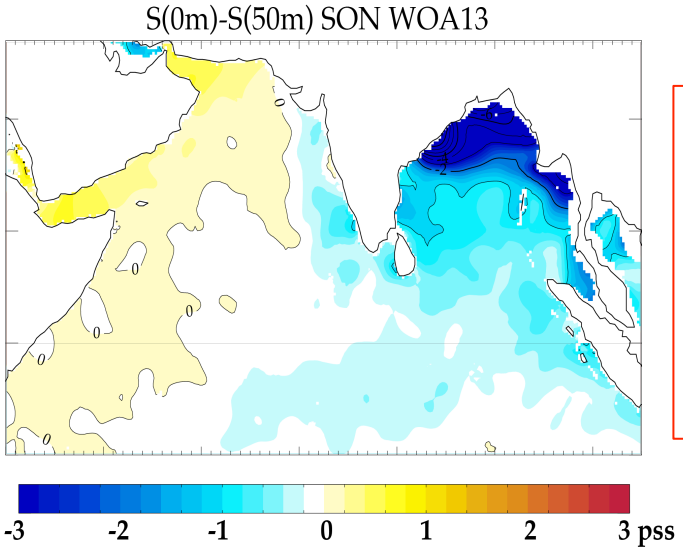
inhibits vertical mixing

→ impacts →

- Monsoon (Shenoi et al., 2002)
- Cyclones (Sengupta et al., 2008)
- Productivity (Prasannakumar et al., 2002)

Introduction





Strong surface freshening

↓

Stable stratification

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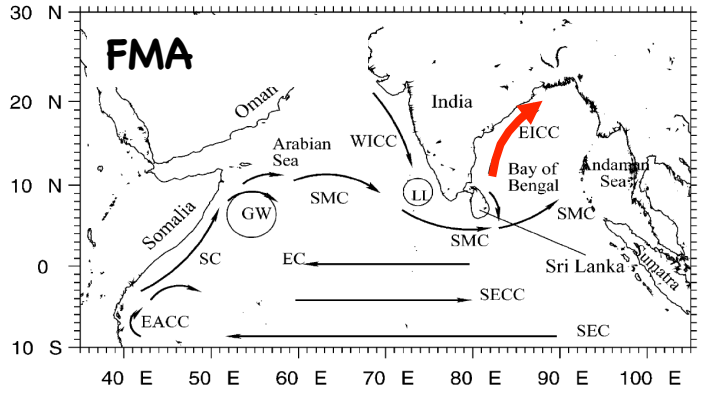
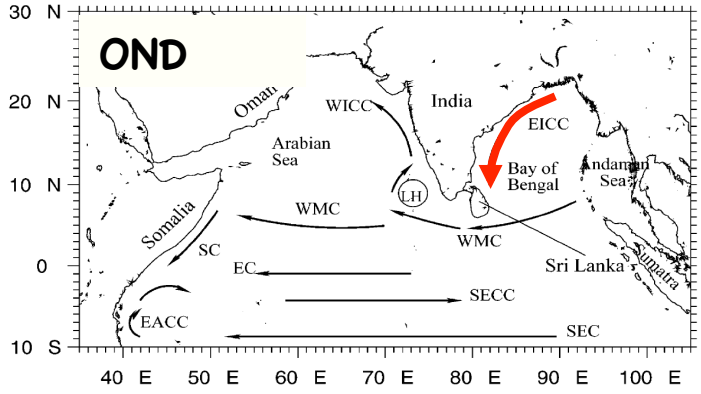
inhibits vertical mixing

- Previous studies described the effect of salinity on vertical mixing.
- But not its potential effect on pressure gradient.

Schematic - surface Current





[taken from *Shankar et al.*, 2002]

Introduction

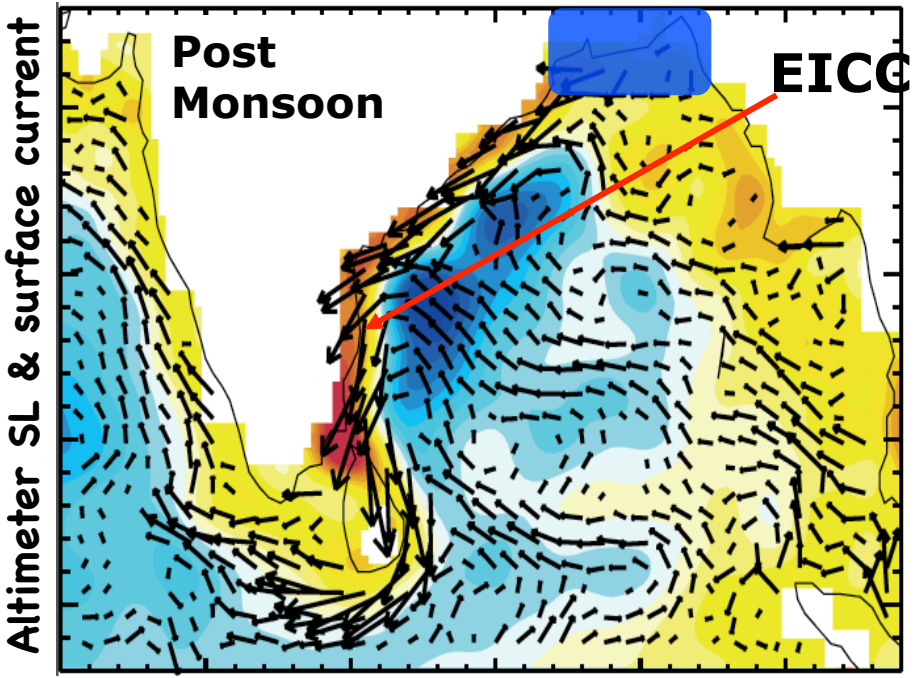
Seasonally reversing monsoon winds force seasonally reversing circulation.

- Major current in BoB : East Indian Coastal Current (EICC)

- EICC - seasonally reversing western boundary current
  - Pre Monsson : EICC flows northward.
  - Post Monsoon : EICC flows southward.

Introduction

Ganges freshwater input

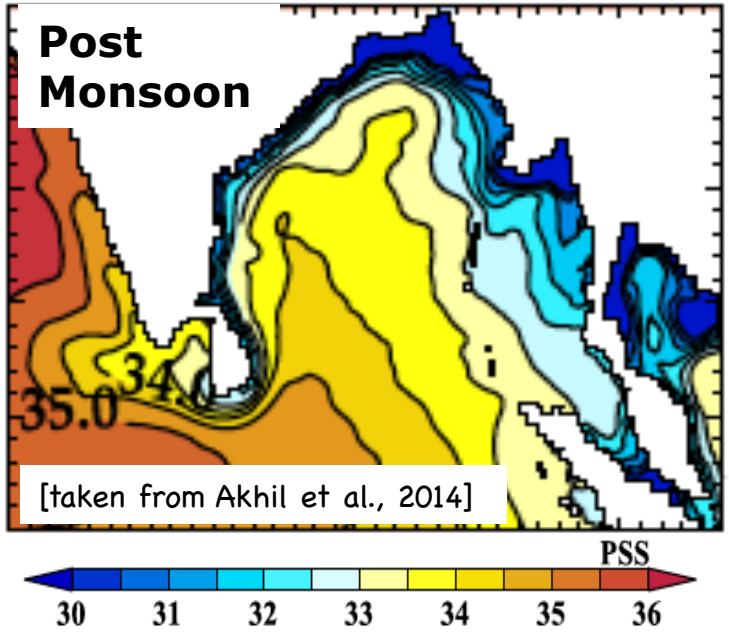


EICC

- Coastally trapped
- Flows southward during post monsoon
- Carries Ganges fresh water southward
- Drives strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)

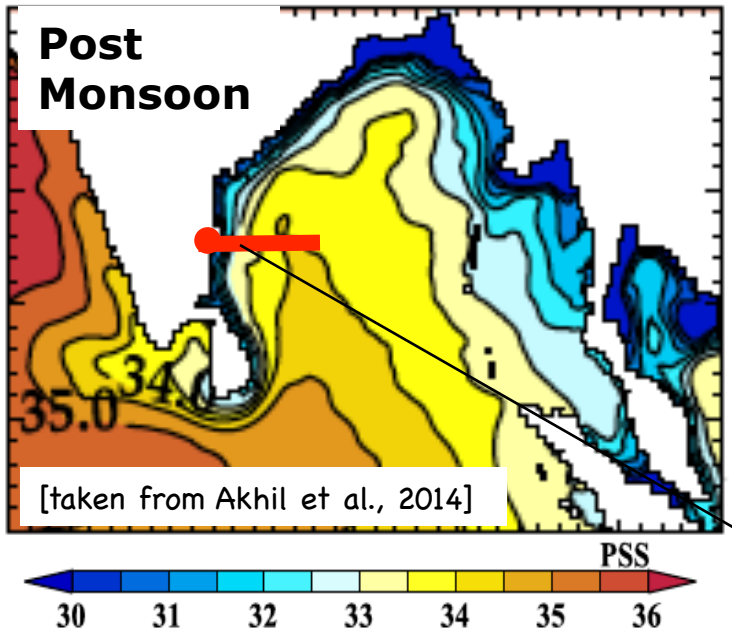
Introduction

Model SSS

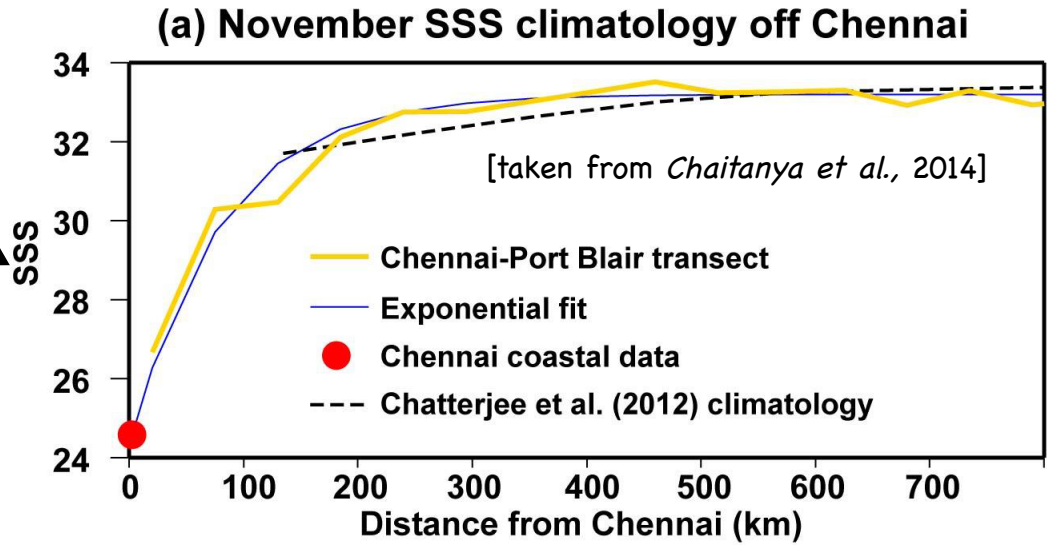


- Strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)

Introduction



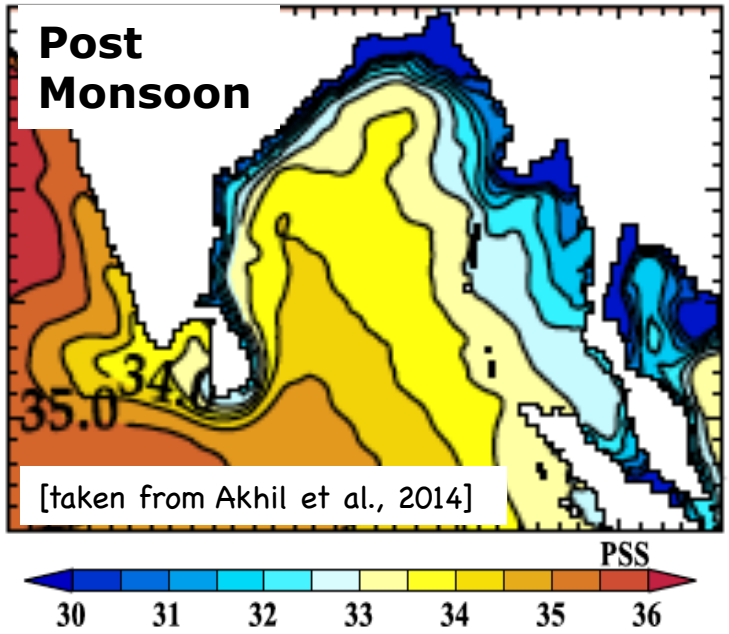
- Observational study revealed a narrow (50-100 km wide) freshening along the coast of India –'river in the sea'- in agreement with the model result.



- Strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)

Introduction

Model SSS



Question: Contribution of horizontal salinity gradient to the EICC?

- Strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)

Data & Methods

Model: NEMO OGCM

(1/4°) regional BoB configuration

Interannual rain (GPCP) & satellite-derived runoffs (following Papa et al. [2012])

No relaxation to SSS climatology.

Exp	Description
REF	Control Experiment
NOS	No salinity effect in pressure gradient

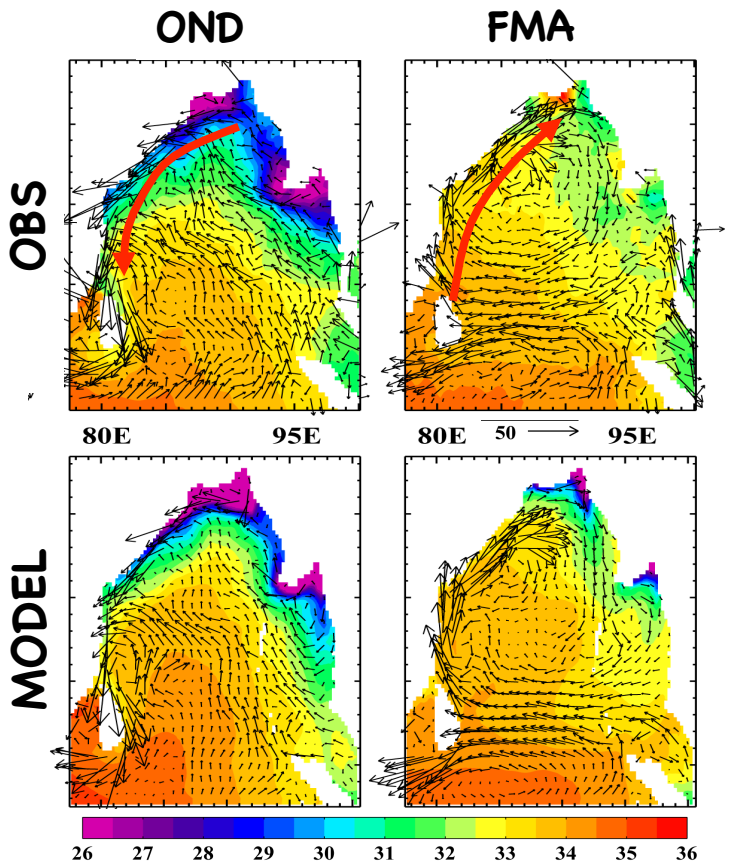
REF-NOS
=
Effect of salinity on pressure gradient

Observations:

SMOS : SSS climatology

GECKO : SL & surface current climatology

SSS & Surface Current

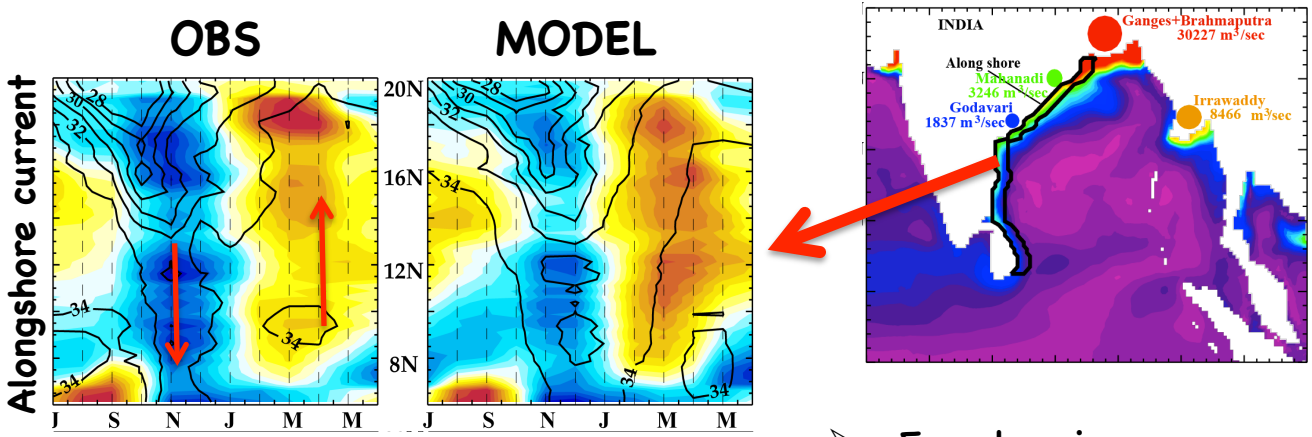


Model Validation

- Captures EICC seasonality (southward during post monsoon - OND; Northward in pre-monsoon - FMA)
- Captures surface salinity seasonality (expands southward along east coast of India during post monsoon-OND; salty during pre-monsoon-FMA)

Model Validation

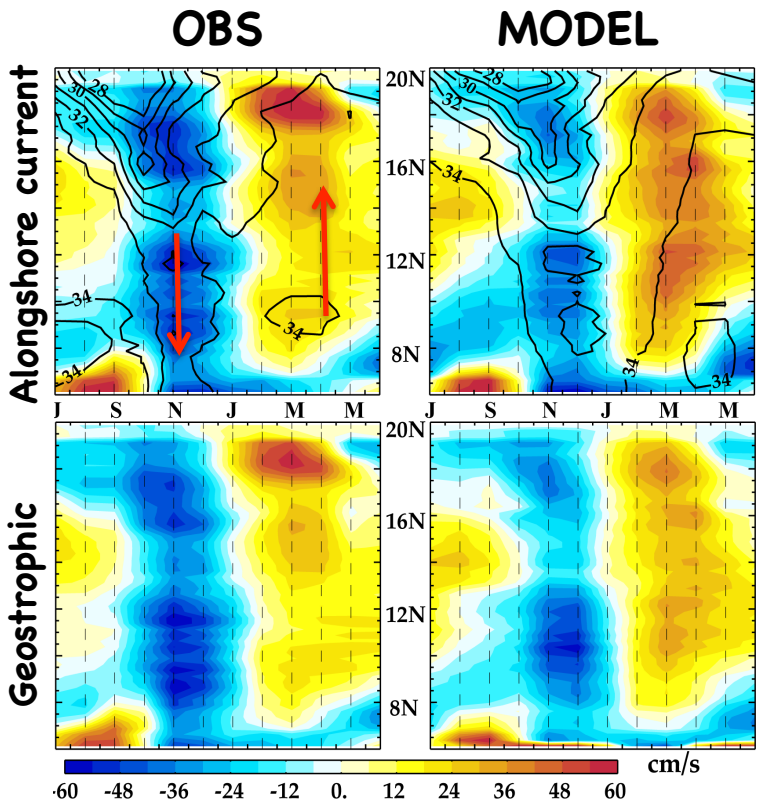
Surface current & SSS along the east coast of India



- Freshening occurs simultaneously with EICC reversal to southward current
- Model accurately represents the seasonal reversal of both SSS & surface current

Surface current & SSS along the east coast of India

Model Validation



- EICC largely geostrophic

Impact of horizontal salinity gradient on EICC

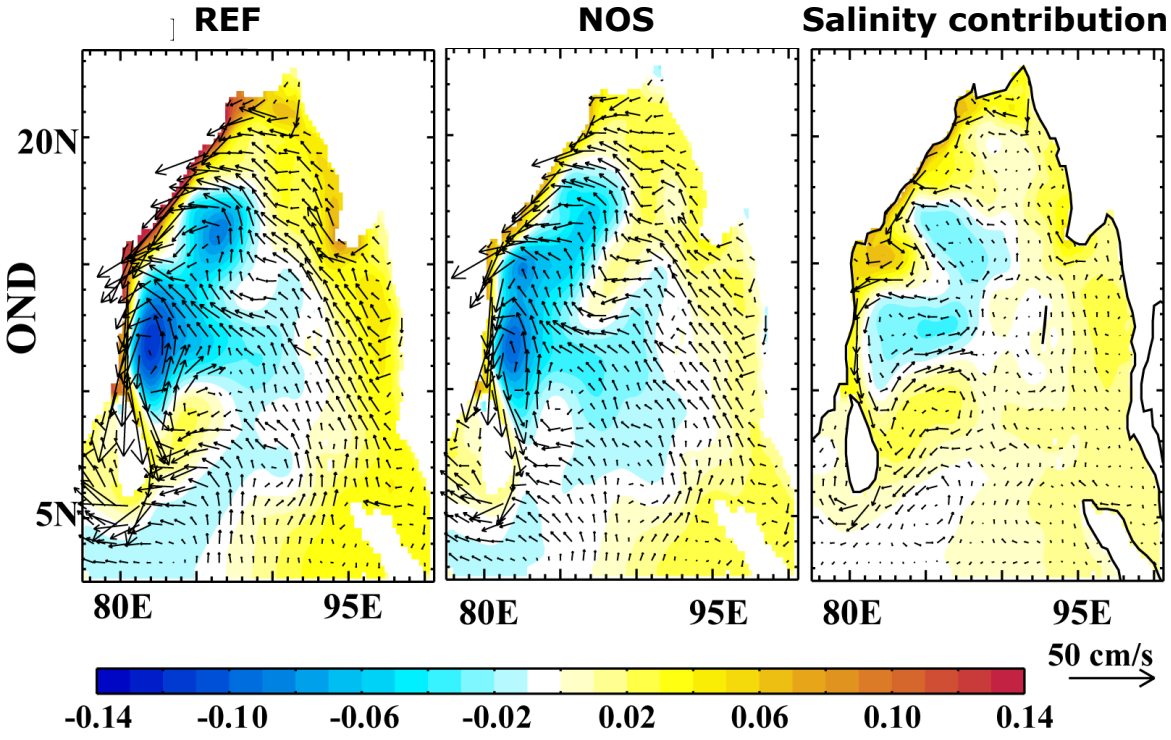
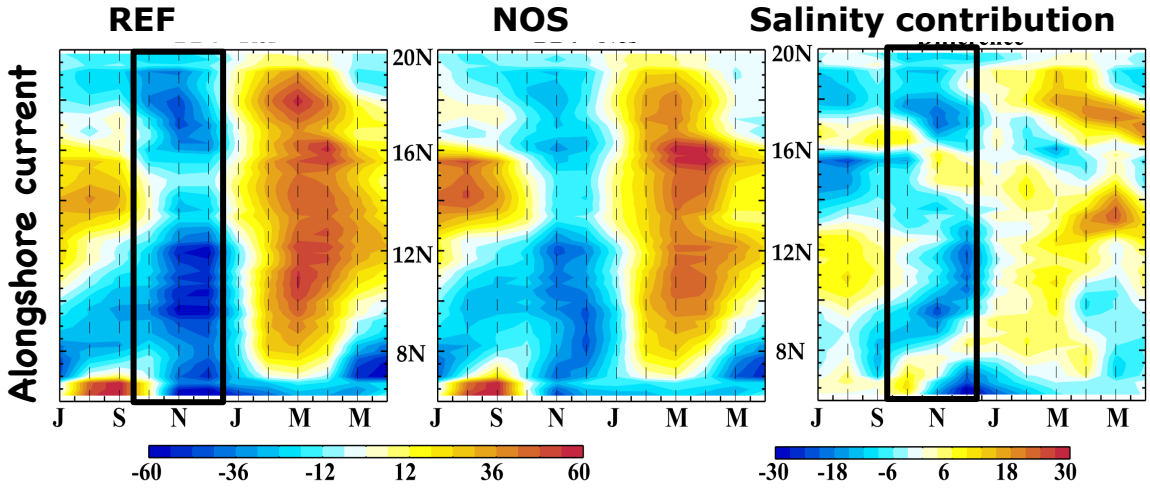


Figure : map of SL anomaly (color) & surface currents (vectors) during OND.

- Salinity gradients contribute significantly to southward EICC in boreal fall (post-monsoon)

Impact of horizontal salinity gradient on EICC

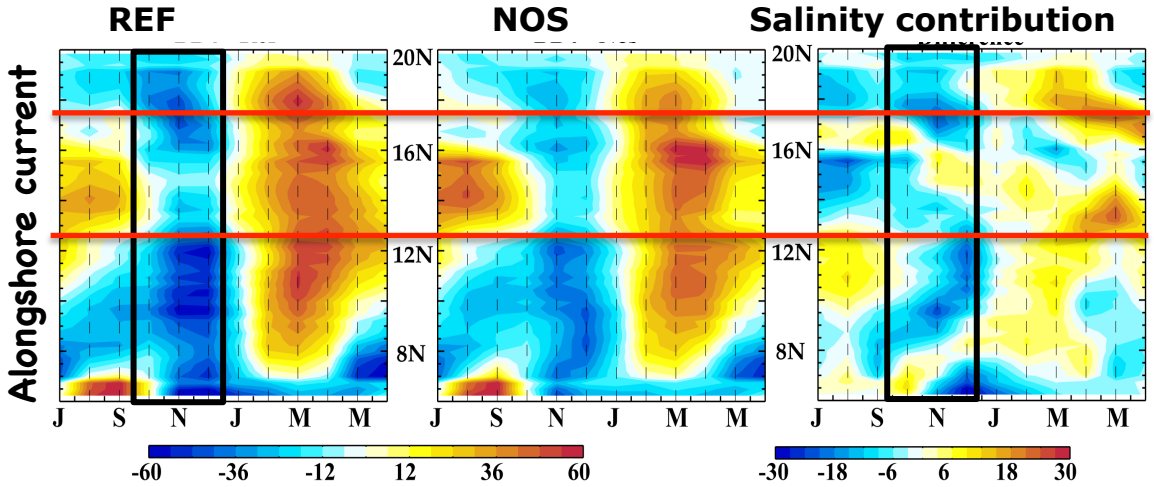
Results



- Salinity-induced gradients reduce the EICC intensity by up to 10-20 cm/s, i.e. ≈40% during Oct-Dec

Impact of horizontal salinity gradient on EICC

Results



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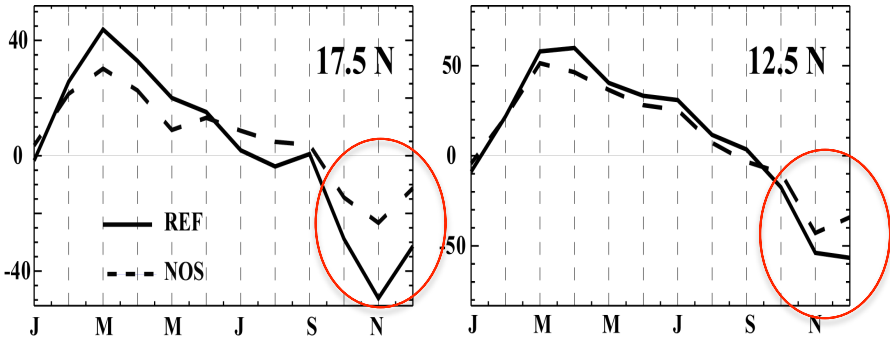
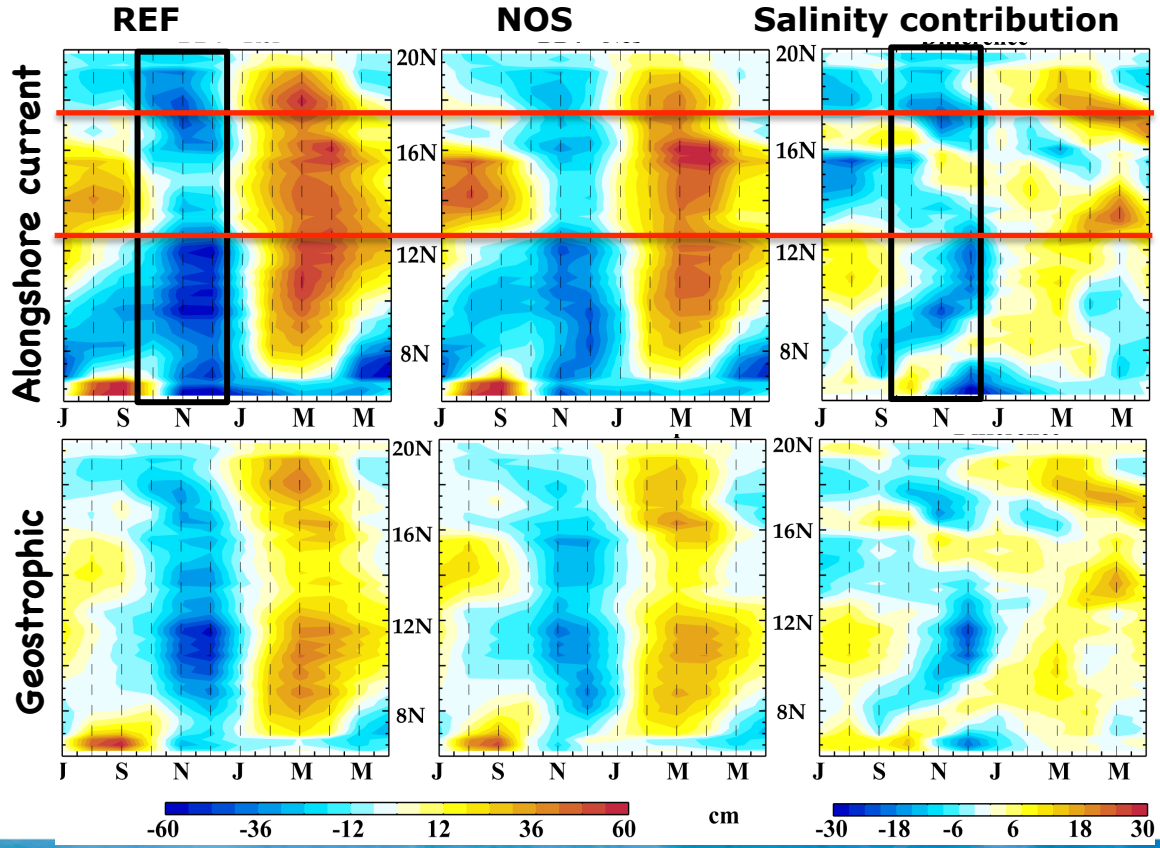


Impact of horizontal salinity gradient on EICC

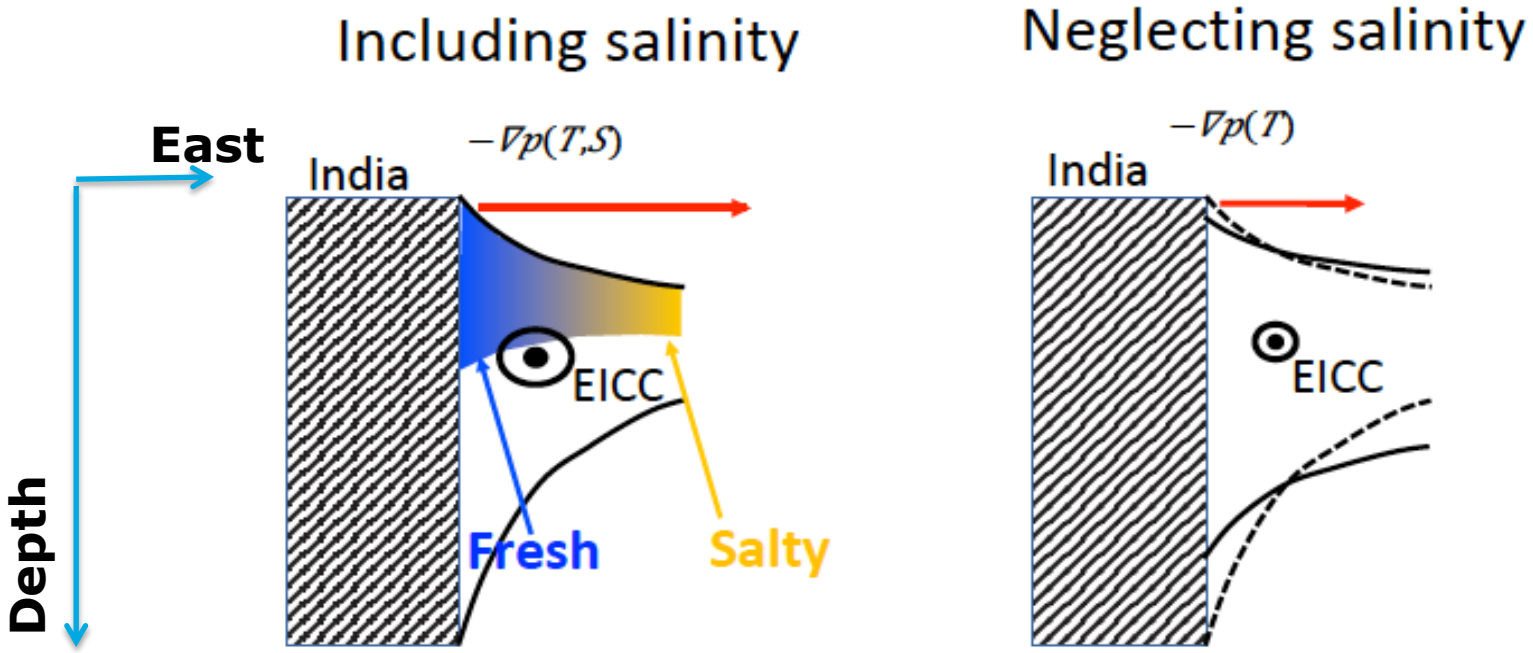
Results



- Salinity-induced gradients reduce the EICC intensity by up to 10-20 cm/s, i.e. ≈40% during Oct-Dec
- EICC decrease is largely geostrophic (i.e. associated with salinity-driven pressure force)

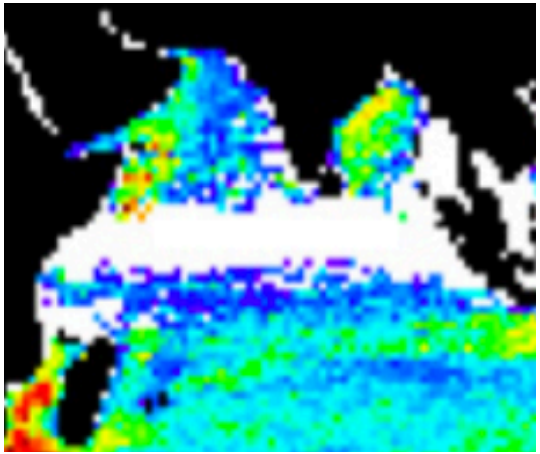
Impact of horizontal salinity gradient on EICC

Results



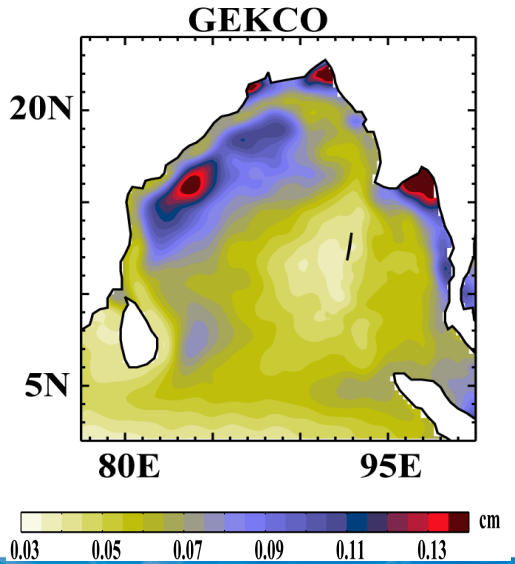
- Salinity gradients contribute to ~40% of the EICC intensity.

Impact of horizontal salinity gradient on Eddies



- Large number of Eddies in BoB (chelton et al., 2011)
- Maximum eddy variability is along the western BoB (chelton et al., 2011)

- Observation (Gecko – SL) also shows similar result



Impact of horizontal salinity gradient on Eddies

Generating mechanisms of eddies

- Barotropic instability (favoured by strong horizontal shear)
- Baroclinic instability (favoured by strong baroclinic pressure gradients)

Salinity:

- River in the sea strongly stratified: strong baroclinicity
- Salinity contributes to eddies amplitude?

Impact of horizontal salinity gradient on Eddies

Results

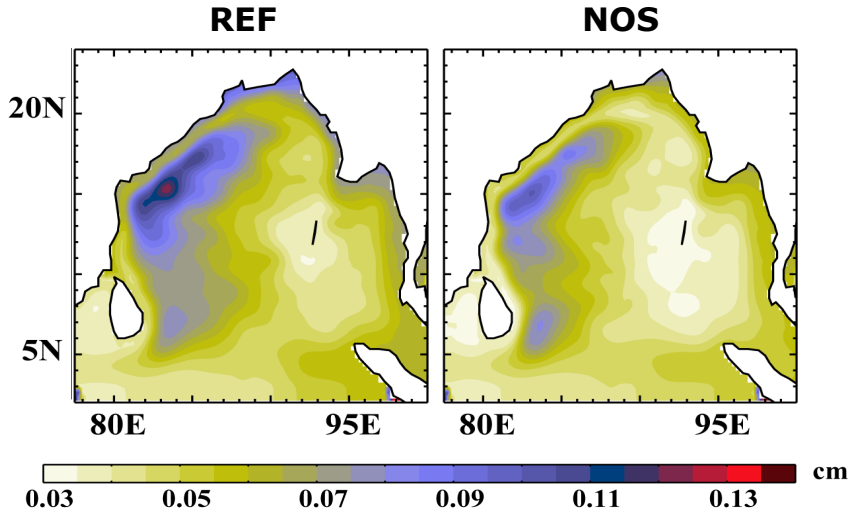


Figure : STD of SL anomalies

- Model reproduces (underestimates) eddy variability in the western BoB (near the EICC)

- Neglecting salinity gradients drive a ≈ 30% reduction in eddy variability in this region
- Mechanism: reduction of baroclinic instabilities associated with the near-surface salinity gradient at the EICC / river in the sea edge ?

Conclusion

- Horizontal salinity gradients contribute to up to ≈40% of EICC intensity after the summer monsoon.
- Salinity gradients enhance mesoscale variability by up to 30% in the western BoB
- Robust results in a similar 1/12° experiment

Conclusion

- **Positive Feedback Loop**

EICC forms the 'river in the sea' (Akhil et al 2014; Chaitanya et al., 2014)

'river in the sea' strengthens EICC (keerthi et al 2018, in preparation)

Thank You